



Review

Commercial fishing industry deaths – Forensic issues

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ABSTRACT

The commercial fishing industry has one of the highest injury and mortality rates of all occupational areas. This results from the nature of the work involving vessels often manned by only a few individuals who are working with heavy-duty equipment in dangerous environments at all hours. Economic pressures may force inappropriately geared vessels to operate further out to sea than is safe. Deaths result from a wide variety of situations involving vessel loss, falls overboard, fire and explosions, cable entanglements and gas exposure. Autopsies are often difficult as there are no diagnostic features of either drowning or hypothermia and features may be obscured by putrefaction and postmortem animal predation. The forensic implications of deaths in the fishing industry are reviewed.

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1. Introduction

Working in the commercial fishing industry has always been associated with high rates of injury and death.¹ Small craft manned by only a few individuals working with a range of equipment in dangerous environments during the day and night in inclement weather are all factors that may contribute to poor outcomes. Fifty-nine percent of cases in one Danish study involved small, one-man-operated craft. Fatigue has also been cited as a problem by fishermen that increases with the length of the period at sea.² Grounding on rocks or at harbour entrances has been documented in conditions of poor visibility or at night when watchmen were either fatigued or had fallen asleep.³ Fatigue is contributed to by long working hours at sea with short rest periods, cramped sleeping spaces, interruption of sleep by engine noise and vibration and the effects of heavy seas.³

A study of small-scale Polish fishing showed a significantly higher death rate in small boats (<13 m), with alcohol being implicated in the deaths in 45% of the cases where autopsies were performed.⁴ The types of lethal injuries vary, however, with the other end of the spectrum being represented by large catcher–processor (factory trawler) vessels which combine the risks of fish catching with those associated with operating large-scale commercial food processing and canning machinery.⁵ The range of potentially lethal injuries and situations is extensive, with particular forensic issues arising that may not be encountered in

other occupational deaths. Deaths are often attributed to drowning or ‘missing at sea’.⁴

In the United Kingdom, fisherman have had death rates from accidents that are 52.4 times (95% confidence interval (CI) 42.9–63.8) higher than other British workers. Although the number of deaths has declined in recent decades, the relative risk has not changed.^{1,3} As detailed below, deaths may be related to loss of the vessel and crew, or to personal accidents.

This article provides an overview of the types of fatalities that may occur in commercial fishing and analyses medicolegal issues that may be encountered with such deaths at autopsy. It is recognised that it is sometimes difficult to separate out the exact numbers of deaths in the fishing industry from other occupations when national data are being used, as fishing industry deaths may be grouped with “transportation, construction and other agricultural deaths.”⁶ In addition, in the United Kingdom, for example, deaths at sea may have been considerably underestimated as they may not have been listed with the local registrars of death or included in routine national occupational mortality statistics.³ However, such data as exist can still provide a useful guide as to the nature of deaths that occur.

2. Deaths related to loss of a boat

In the United Kingdom, trawler fishing has had the highest mortality rates due to occupational hazards on board and to weather-related dangers.¹ Deaths may occur when a vessel has foundered (capsized or disappeared) in adverse weather, grounded, collided or had the net snag on a shipwreck or other underwater

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hazard.¹ Each of these types of events may be associated with a particular part of the coastline.⁷ Flooding, propeller entanglement and being struck by a large wave may also cause problems.^{8–10} In a review of 1039 fatalities from accidents in fishing vessels registered in the United Kingdom from 1984 to 2008, 65% were caused by foundering of the vessel, 21% by grounding and 7% by collisions.⁷ Whereas in the past, severe weather and sea conditions have been mainly responsible for vessel loss, recently, these events have been attributed more to ‘unstable, overloaded and unseaworthy’ vessels. Modifications of vessel construction or rigging, and overloading or loading of catch on the deck have all led to decreased stability, particularly during the hauling in of fishing gear.^{2,7} Depletion of closer inshore fishing grounds may also result in fishermen going further out to sea in smaller, less adequate vessels.³ The speed with which vessels sink may mean that crew simply does not have time to put on personal flotation devices, launch life rafts or send distress signals.³

Specific difficulties that arise in the forensic assessment of such deaths are influenced significantly by failure to find bodies after disasters in the open sea. Even if bodies are found, the autopsy assessment may be complicated by the effects of prolonged immersion, as detailed below.

3. Other deaths

High rates of fatal accidents are found in fishing fleets in all parts of the world with rates of 145, 143 and 116 per 1,000,000 worker years being found in Danish, Australian and Alaskan waters. These correspond to relative risks to other workers in those countries of 53, 18 and 26.¹

3.1. Falls overboard

Lethal falls overboard have been defined as “unintentionally entering the water outside the hull of a commercial fishing vessel resulting in a fatality.”¹¹ Such falls have been documented particularly on trawlers when shooting out or hauling in of nets, and are often associated with adverse weather conditions. For example, conditions with gale force 8 or more were recorded in 14 of 50 such deaths in the United Kingdom.¹ Fishermen may be knocked overboard by equipment or may be caught in nets or lines and dragged overboard. An unusual case has been reported where a fisherman was dragged overboard and drowned when a large fish hook penetrated his wrist beneath the flexor tendons, effectively tying him to the outgoing line.¹² Other causes include slipping or losing balance on a moving and slippery surface, poor visibility or being washed overboard by a wave. Alcohol was involved in 20–30% of cases in a study by Lucas et al.¹¹

Falls overboard account for 25% of fishing fatalities in the United States, and between 20 and 33% in other countries including Iceland, Norway, Denmark, Ireland and Canada.¹¹ The risk of falling overboard is dependent on the type of fishing boat and gear used; for example, falls are three times more common among shellfishers than salmon fisherman, with 82% of cases involving only three gear types: pot gear, gillnet and long lines. Gear entanglement was a more significant event with pot gear used on shellfish vessels than with gillnets used on salmon boats.¹¹

Recommended steps to reduce falls overboard have included keeping decks clear of unnecessary nets, lines, ropes and other obstacles; regularly removing ice and oil; providing boots with good grips and a non-slip decking; and increasing the height of side railings.³

Numbers of cases where bodies have not been found are higher with losses overboard from larger vessels as these are able to operate in open sea further away from land than smaller crafts. This

reflects the greater difficulties that arise with rescue attempts in the open sea and also the complexities of scouring a death scene that may be markedly affected by weather and tidal currents.

A number of deaths have also occurred with falls overboard when crew have been returning to vessels docked in port. Lack of familiarity with a particular dock, jumping from the wharf to the gunwale and intoxication may all be involved. In addition, darkness and foreign ports were a feature of one Danish study.² The author had a case in Tasmania where a fisherman who had disappeared one evening was found in the water beneath his vessel several days later. Cadaveric spasm had occurred and when found he was still holding the case of beer that he had been carrying at the time of his fall.

Evaluation of these cases requires full toxicological screening; however, prolonged postmortem intervals may complicate interpretations. Evaluating whether an injury occurred before the decedent fell into the water, during the process of falling, while alive and in the water or after death, may also not be possible.

3.2. Head injury

Traumatic brain injury is responsible for significant numbers of work-related deaths every year in industrialised countries. Those at highest risk are males aged 65 years and over.⁶ In the United States nearly 7300 work-related deaths due to traumatic brain injury were registered between 2003 and 2008 with construction, transportation and agriculture/forestry/fishing accounting for nearly 50% of the cases.⁶ The death rate per 100,000 in the ‘fishing, hunting and trapping’ category of 3.2 closely matched that of 3.4 in the mining section under ‘coal, metal ore, non-metallic, not specified’. Reasons for head injury in the fishing industry are not hard to envisage with workers operating heavy equipment on slippery and mobile decks. Falls and impact with heavy machinery account for the majority of cases. Blunt trauma from equipment involves being impacted by blocks, booms, cables, steering bars and trawl doors.² At autopsy, patterned injuries from particular pieces of equipment may be found, and comparison of the types of injuries with information provided by work site inspection will enable determination of the likely sequence of terminal events. Individuals may be at a higher risk of lethal head injury from blunt trauma if they are intoxicated.¹³

3.3. Inhalational deaths

Carbon monoxide inhalation was by far the most common cause of fatal occupational inhalation in the United States in the 1990s, accounting for more than three times the number of deaths than the next category of sulphur and sulphur compound inhalation.¹⁴ Particular situations relevant to fishing boats include performing machinery repair or maintenance with motors running in unventilated or closed environments. There may be more than one body found under these circumstances, with cherry pink discolouration of the skin and tissues being clues at autopsy to the cause and manner of death. The toxicological part of the autopsy assessment in deaths on fishing boats should, therefore, include routine measurement of blood carbon monoxide levels.

Other lethal situations have arisen when damaged refrigeration units on fishing vessels have leaked freon, a halogenated hydrocarbon that displaces air, as well as inducing lethal cardiac arrhythmias.^{15,16} Displacement of oxygen by inert gases such as methane is a well-recognised problem in silos and sewers on land¹⁷ and has also been reported in fishing vessels associated with the anaerobic decay of poorly refrigerated fish in unventilated holds or from decaying organic material in the bilge. Gases included ammonia, hydrogen sulphide, carbon monoxide and carbon

dioxide.¹⁸ On-site inspection of the vessel with testing of the atmosphere and equipment will provide crucial information for the pathologist.

3.4. Fires/explosions

Fires and explosion have been responsible for approximately 5% of deaths in British fishing vessels over the past 60 years with mortality highest at night.⁷ Any vessel that has an enclosed engine room runs the risk of an explosion if volatilised fuel is not adequately removed, as the flammable properties of the mixture are determined by the ratio of fuel vapour to air. At a certain level, the speed of combustion is so rapid that an explosion may occur.¹⁹ A series of cases were reported from China where broken-down scavenger fans had caused a dangerous build-up of fuel vapour. Other reported situations included fires caused by welding, and fires started by smoking in the fuel compartment.²⁰ Autopsy examinations follow routine procedures for fires and explosions.

3.5. Cable entanglement

In addition to being entangled in gear going over the side, fishermen may get caught in cables being wound onto trawl drums. Entrapment in winches may cause severe blunt-force trauma or crush asphyxia. A problem that has been identified is that although these machines should stop automatically if the handles are not activated, this function may be not working or may have been deliberately bypassed.² Crush asphyxia will be identified at autopsy by parchmented marks across the chest or abdomen, sometimes with a pattern that corresponds to the particular object that the decedent was compressed by or pressed against.²¹ Intense upper chest, neck and facial congestion with petechiae and small ecchymoses are also typical.

3.6. Animal-related deaths

Deaths from animal attacks, or actions, may occur both in the water and on fishing boats. Marine predator attacks usually involve sharks and have been well documented in abalone divers.²² Attacks may assume different forms with cases where a single limb has been bitten/amputated, contrasting with others where the body has been literally torn to pieces.²³ Other injuries may involve crush/blunt trauma from large fish on deck, or punctures/lacerations from spines that tend to cause non-lethal infections. Stings and barbs from stingrays and catfish are rarely lethal.²⁴ Although toxins from fish and urchins generally do not kill, incidental netting of Portuguese Man-of-War, a jellyfish with long stinging tentacles, or blue ringed octopus, may increase the risk of significant envenomation.²⁵ More likely are falls from slipping on jellyfish on the deck.²⁶

3.7. Diving deaths

Deaths while using diving equipment may result from equipment failure, inadequate oxygen or from hazards related to the aquatic environment including entrapment in seaweed or in caves, or injury from predators or vessel propellers.²⁷ Drowning, decompression illness, nitrogen narcosis, carbon dioxide retention and anoxic asphyxia are other problems that may occur^{28,29} and the autopsy examination should be preceded by radiological examination and consultation with a diving specialist.²⁷

3.8. Miscellaneous

A significant component of fishing industry work that is sometimes not considered in the assessment of fishing-related deaths

takes place at the dockside involving unloading, sorting and storing of the catch. For example, agriculture, forestry and fishing came within the top five sectors for fatal workplace injuries associated with forklifts in a study from the United States from 1980 to 1994. Deaths resulted from overturns, being struck or crushed by the forklift, or falling from the machine.³⁰

Anaphylactic reactions have been reported to sodium metabisulphite, a preservative that has been used in the shrimping industry. The deaths of two crewmen who had been applying the powder in the hold of a shrimp trawler raised this possibility, and also the possibility of anoxia from sulphur dioxide that may be released when sodium metabisulphide reacts with water and acids.³¹ In addition to work site measurements of gases, autopsy testing for anaphylaxis by measuring serum tryptase levels may be useful in these circumstances.³²

In addition to economic pressures on fishermen, certain situations such as 'derbys' may increase the risks of injury. These consist of shortened fishing seasons where there is no catch limit. They are scheduled in advance and held despite adverse sea and weather conditions.⁵ Seasonal employment in the Alaska fishing industry by college students has also been noted as a possible problem, by exposing individuals with limited experience of the fishing industry to difficult and potentially dangerous work environments.⁵

4. Circumstances of death

When a crew member is lost overboard and the body is not found, it is not possible to determine a precise cause of death and so sometimes the generic terminology 'missing at sea' will be used.⁴ This reasons for this are obvious, as there are many possibilities: for example, the victim may have sustained significant blunt trauma if he was forcibly dragged overboard; may have had neck compression from nets, lines or cables; may have drowned; or may have succumbed to hypothermia (depending on the water temperature and weather conditions). Hypothermic deaths are contributed to by a lack of thermoprotective clothing and delay in rescue.⁴

As noted, alcohol use has been documented in a significant percentage of victims in fishing industry deaths⁴ and may have led to multiple adverse effects including navigation errors, misinterpretation or ignoring of weather conditions, misuse of machinery or loss of balance. Once in the water, alcohol will increase temperature loss hastening the onset of lethal hypothermia.³³

While drowning is a quite likely terminal event, hypothermia may play a significant role. Sudden and unexpected cold-water immersion may cause death within minutes due to cold shock, or within 3–15 min due to so-called 'swimming failure'. Hypothermia may take some time to develop, depending on the temperature of the water, but may result in death even after rescue. Temperatures less than 15 °C are particularly dangerous due to their association with both cold shock and swimming failure. Criteria for each of these situations have been published previously.³⁴

5. Issues at autopsy

All deaths involving commercial fishing boats should be subject to standard workplace investigations determined by local jurisdictions. Autopsies in cases of fishing industry deaths may, however, be difficult as there are no diagnostic features of either hypothermia or drowning, although an elevated vitreous sodium will confirm saltwater immersion.^{33,35–37} It may also have taken some time for a body to be found, so that there may be superimposed changes from putrefaction and postmortem animal predation.³⁸ Distinguishing antemortem from postmortem injuries

may not be possible in decedents who have gone overboard and been in the ocean for some time, although injuries from cables or fishing lines may still be obvious.^{12,27} Specific steps will need to be taken at autopsy in cases of fatal shark attack and in diving deaths.³⁹ Postmortem toxicology may still be able to provide useful information on alcohol or drugs that may have impaired responses.

Identification may be an issue, particularly if a body has been found in an area frequented by fishing fleets from a number of countries, or has been in the water for some time. Despite this, successful identifications may occur even after many years. This was exemplified by the identification of a pair of skeletonised feet in rubber boots dredged up from a depth of 145 m, approximately 185 km off the southern Australian coast in the Great Australian Bight. Dark, cool and alkaline conditions on the floor of the ocean had preserved DNA, enabling matching with the family of a fisherman who had gone missing a decade earlier.⁴⁰

Thus, deaths at sea bring with them a number of unique challenges that are not found with deaths on land. Careful integration of the findings from examination of the vessel and associated equipment, with reports of the weather and sea conditions at the time of death, and the autopsy, may enable a reasonable assessment to be made as to the most likely cause, mechanism and manner of death.

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